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Research Article

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# Soil acidity characterization under different land use systems of Mizoram

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## Summary

The pH of the soil is the most important characteristic in determining fertility of the soil. Soil reaction (pH) affects various physical, chemical and biological properties of soils. Upland soils are usually characterized as highly erodible, leached in Mizoram and mostly soils are acidic to varying degree. Soils in their reaction varied from 4.79 to 6.14 in Kolasib district, 4.7 to 6.65 in Mammit district, 4.99 to 5.76 in Aizawl district, 4.51 to 5.71 in Serchip district, 4.59 to 6.49 in Lunglei district, 4.96 to 6.03 in Lawangtalai district, 5.94 to 7.24 in Saiha district and 4.99 to 5.92 in Champhai district . The organic matter content varied from 0.4 to 4.14 per cent with an average value of 2.22.

**Key words :** Soil, Acidity, Land use

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## Introduction

Mizoram is a hilly terrain lying in the Eastern-most corner of India. The physiography of Mizoram is divided into hills, valley and flat lands. It has a sub tropical and humid climate, which favours the growth of a large number of agri-horticultural crops. Land forms in upland vary from low-lying valley bottoms to undulating and steep sloping lands with high runoff. The land is cleared every year and vegetation slashed and burnt *i.e.* slash and burn cultivation. Upland soils are usually characterized as highly erodible, leached in Mizoram. Soils are acidic to varying degree (Singh *et al.*, 1991). Soil acidity affects soil fertility, nutrient availability and the biological activity of the soil. Different plants are affected by soil acidity at different pH values in the one soil. Furthermore, for a given plant, acidity problems occur at different pH values on different soils. The land use systems are of great value to achieve sustainable production on marginal lands under northeastern hilly region. To effectively manage the soil resource, knowledge of its level of acidity and subsequent characterization is a key requirement.

The degree of soil acidity is known to exert an adverse effect on crop growth by influencing nutrient availability and microbial activity (Barrow, 1967). Soil acidity also has a direct effect on the survival and growth of *Rhizobium* bacteria. Aluminium toxicity restricts root growth and reduces the yield of crops grown on acid soils. Substantial amount of soil acidity is found in the soil solid phase, in the interlayer spaces and in the functional groups of organic matter (Bolan *et al.*,1985). All these contribute to the pool of soil acidity.

Soil acidity has different components. On the basis of the extractability of exchangeable $H^+$ and exchangeable $Al^{3+}$ ions, various forms of soil acidity have been categorized *viz.*, total, exchangeable, active and potential or non-

exchangeable acidity. The active soil acidity is the $H^+$ ion concentration that is measured by a pH meter. Exchangeable acidity includes exchangeable $Al^{3+}$ and exchangeable $H^+$. Exchange acidity, is the sum total of $H^+$ and $Al^{3+}$ retained on the soil exchange complex. The non-exchangeable acidity is the hydrogen and aluminium ions associated or bounded with the organic matter and clays in the soil. The amount of acidity associated with this fraction of the total acidity in the soil ranges from 1000 times to 100000 times of that found in solution depending on the soil texture and organic matter level. Exchangeable acidity and non-exchangeable acidity are the reserve acidity in the soil. Soil pH is not indicative of the reserve or potential acidity. It is into this background that the present study was aimed to find out the types of soil acidity in some selected soils of Mizoram.

## Resource and Research Methods

Six hundred soil samples (0-15 cm depth) were collected from twenty one out of twenty three rural development blocks of Mizoram. The major land use systems from which soil samples were collected were Jhums, uplands, wetland rice cultivation (WRC), forests, fallow of different periods, orchards. The soil samples were dried and processed. The soils were sieved with a 2 mm sieve. Soil pH was determined with the help of a pH meter in 1:2.5 :: soil : water suspension following the method of Jackson (1978). Electrical conductivity was determined in the soil suspension in which pH was measured following the method of Jackson (1978). Total acidity was estimated by extracting with 0.5M $BaCl_2$-TEA buffered to pH 8.2 (Peech *et al.*, 1962). Per cent acid and aluminium saturation for all the soil samples were calculated for categorizing soils into different categories of aluminium toxicity. Twenty soil samples were selected out of these samples based on their pH falling under above classes of soil acidity. Total acidity in the soils was estimated by Kappen (1934) method. Exchangeable acidity was determined by Sokolov and Sorokin (1958) method. Total potential soil acidity or exchangeable $H^+$ was determined by extracting with $BaCl_2$ – TEA reagent as described by Peech *et al.* (1962). Non-exchangeable acidity was determined by difference methods. Active acidity was determined by taking the negative logarithm of $H^+$ ion concentration.

## Research Findings and Discussion

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

**Soil characteristics :**

Twenty three per cent soils sampled were found to be strongly acidic where soil pH varied from 5.1 to 5.5. Twenty two per cent soils sampled were found to be very strongly acidic where soil pH varied from 4.5 to 5.0. Twenty nine per cent soils sampled were found to be medium in acidity where soil pH varied from 5.6 to 6.0. Twelve and ten per cent soils sampled were found to be slightly acidic and neutral where soil pH varied from 6.0 to 6.5 and 6.6 to7.3, respectively.

**Status of acidity under different land use systems in Mizoram soils :**

The soils under different land use systems reflected variation in soil reaction properties. Large differences between plant species occur in their suitability to varying levels of soil acidity. In Kolasib district, arecanut soils had pH of 5.09 and 5.23 *i.e.* strongly acidic and banana and citrus had less than 5.0 pH *i.e.* very strongly acidic (Table 1). The soils under wetland rice cultivation were slightly acidic. The soils of WRC are subjected to varying level of moisture regimes and submergence of these soils for different periods increases soil pH towards neutrality. This is one reason why WRC lands are highly fertile. Bringing soil pH around 6.0 pH will result in most of the nutrients in available form. In Mamit, soils under teak forest had soil pH of 5.34 *i.e.* strongly acidic, whereas bamboo had soil pH of 5.53 *i.e.* moderately acidic soils and WRC fields soils were neutral to moderately acidic. In the citrus declined orchards soil pH varied from 4.7 to 5.52. In Aizawl, soils supporting large scale chow-chow cultivation were having soil pH varying from 5.25 to 5.75 *i.e.* strongly acidic to slightly acidic. Citrus and banana soils in Aizawl had soil pH of 5.76 and 5.52 *i.e.* slightly acidic. In Serchip, soils under banana had a mean pH value of 4.51 *i.e.* very strongly acidic. However, soils under passion fruit, WRC, citrus and pine forest were 5.71, 5.29, 5.24 and 5.5, respectively.

Soils in Lunglei district had also a large variation in respect of soil pH. Wetland rice cultivation (WRC) soils were having mean pH values of 6.14 and 6.05 and Ramtharveng terraced soils had soil pH value of 5.8 *i.e.* moderately acidic. Soils under pineapple were having mean pH value of 4.59. Jhums of Lunglei had relatively higher soil pH of 6.49 and 5.91. Teak soils had pH of

**Table 1: Values of soil reaction under different land use systems**

| Place/village | Land use | pH | EC (dS/m) | OC (%) | OM (%) | CEC (meq/100g) |
|---|---|---|---|---|---|---|
| **Kolasib** | | | | | | |
| Vairengte | Arecanut | 5.09 | 0.32 | 1.42 | 2.44 | 9.77 |
| Saipui | WRC | 5.89 | 0.50 | 0.65 | 1.12 | 8.78 |
| Chempai | WRC | 5.95 | 0.42 | 0.78 | 1.34 | 10.53 |
| Meidum | WRC | 6.14 | 0.63 | 0.98 | 1.69 | 13.23 |
| Bhuchang | WRC | 5.92 | 0.20 | 0.23 | 0.40 | 3.11 |
| Bairabi | WRC | 6.08 | 0.36 | 0.63 | 1.09 | 8.51 |
| Bualpui | Banana | 4.79 | 0.08 | 1.78 | 3.07 | 12.27 |
| Kawnpui | Banana | 5.09 | 0.14 | 1.26 | 2.17 | 8.69 |
| Thingdawl | Citrus | 4.84 | 0.24 | 1.22 | 2.10 | 8.41 |
| Hartuki | Hatkora | 5.23 | 0.44 | 1.11 | 1.91 | 7.65 |
| **Mammit** | | | | | | |
| Zamuang | Teak forest | 5.34 | 0.22 | 1.44 | 2.48 | 11.38 |
| Saikhtlir | Bamboo | 5.53 | 0.15 | 1.49 | 2.57 | 7.98 |
| Chunvel | WRC | 6.65 | 0.35 | 1.17 | 2.02 | 10.84 |
| Knahmun | WRC | 5.58 | 0.19 | 1.83 | 3.15 | 11.16 |
| Ruipuichip | Citrus (declined) | 4.7 | 0.01 | 0.95 | 1.64 | - |
| Tuidam | Citrus (declined) | 5.66 | 0.05 | 0.85 | 1.47 | - |
| Mamit | Citrus (declined) | 5.33 | 0.02 | 0.96 | 1.66 | - |
| Kawarthaven | Citrus (declined) | 5.52 | 0.12 | 0.96 | 1.66 | - |
| **Aizawl** | | | | | | |
| Darlawn | Terraces (veg.) | 5.25 | 0.26 | 1.17 | 2.01 | 10.42 |
| Kapram | Terraces (veg.) | 5.40 | 0.24 | 1.28 | 2.21 | 10.43 |
| Sawlang | Terraces (veg.) | 5.75 | 0.12 | 1.10 | 1.90 | 9.50 |
| Sateek | Terraces | 5.76 | 0.53 | 0.98 | 1.69 | 8.43 |
| Sailsuk | Terraces (veg.) | 5.10 | 0.18 | 1.23 | 2.11 | 9.98 |
| Thenzawl | Terraces (veg.) | 5.53 | 0.46 | 1.17 | 2.01 | 10.42 |
| Pawlrang | Banana | 5.52 | 0.21 | 1.11 | 1.92 | 6.72 |
| Saitul | Citrus | 5.76 | 0.55 | 0.66 | 1.13 | 9.01 |
| Durtlang | Terraces (veg.) | 4.99 | 0.43 | 1.174 | 2.02 | 7.38 |
| SipHir | Terraces (veg.) | 5.74 | 0.54 | 0.99 | 1.148 | 5.482 |
| Sairang | Terraces (veg.) | 5.28 | 0.39 | 0.97 | 1.68 | 6.24 |
| **Serchip** | | | | | | |
| Baktawng | Passion fruit | 5.71 | 0.47 | 1.26 | 2.17 | 9.37 |
| Chingchip | Banana | 4.51 | 0.15 | 1.57 | 2.71 | 11.72 |
| New Town, | WRC | 5.29 | 0.32 | 1.58 | 2.72 | 7.70 |
| Kettum | Citrus | 5.24 | 0.36 | 1.38 | 2.37 | 7.49 |
| Chekawn | WRC | 5.53 | 0.23 | 1.87 | 3.22 | 7.90 |
| N.VanlalpHa | Pine forset | 5.5 | 0.4 | 1.6 | 2.8 | 7.8 |

*Table 1 : Contd……………*

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| | | | | | | |
|---|---|---|---|---|---|---|
| **Lunglei** | | | | | | |
| Sarjuplai | WRC | 6.14 | 0.19 | 1.21 | 2.08 | 8.30 |
| LungpHer | Terraces | 5.80 | 0.21 | 1.28 | 2.20 | 7.80 |
| Ramtherveng | WRC | 6.05 | 0.24 | 1.60 | 2.75 | 8.13 |
| Chanmari | Pineapple | 4.59 | 0.15 | 1.56 | 2.69 | 6.17 |
| Thingfall | Jhums | 6.49 | 0.21 | 1.2 | 2.07 | 8.67 |
| Lalreng | Jhums | 5.91 | 0.20 | 1.11 | 1.92 | 7.95 |
| Rotlang | Bamboo | 5.38 | 0.20 | 1.30 | 2.25 | 7.23 |
| PHaireng | Teak | 5.74 | 0.25 | 1.32 | 2.27 | 7.72 |
| Pungwal | Banana | 5.10 | 0.26 | 1.40 | 2.41 | 6.85 |
| **Lawangtalai** | | | | | | |
| Sailkah | Jhums | 6.03 | 0.22 | 1.16 | 2.00 | 12.18 |
| S.Chawnpui | Tung forest | 4.96 | 0.24 | 1.47 | 2.53 | 12.89 |
| Chongte | WRC | 5.95 | 0.33 | 0.88 | 1.52 | 12.78 |
| **Saiha** | | | | | | |
| Serkawr | Jhums | 7.24 | 0.57 | 2.22 | 3.83 | 16.83 |
| Thingsen | Bamboo | 6.39 | 0.15 | 1.98 | 3.41 | 11.91 |
| Bualpui | Terraces | 5.94 | 0.54 | 2.4 | 4.14 | 10.14 |
| **Champhai** | | | | | | |
| Dulte | Banana | 5.19 | 0.27 | 1.38 | 2.37 | 6.33 |
| Zuatlang | WRC (dry) | 5.92 | 0.27 | 1.31 | 2.26 | 9.08 |
| Tlangsum | WRC (wet) | 5.89 | 0.47 | 1.8 | 3.10 | 12.9 |
| Vapar | Grapes orchard | 5.42 | 0.4 | 1.54 | 2.66 | 9.91 |
| Hnahlan | Grapes orchard | 4.99 | 0.14 | 2.05 | 3.53 | 9.73 |
| Khungleng | Passion fruit | 5.34 | 0.06 | 1.67 | 2.88 | 9.67 |

**Table 2 :Values of different forms of acidity in representative soil samples of different land use systems of Mizoram**

| Sr. No. | pH | EC (dS/m) | Total acidity (meq/100g) | Non-exchangeable acidity (meq/100g) | Exchangeable acidity (meq/100g) | Active acidity (meq/100g) |
|---|---|---|---|---|---|---|
| 1. | 4.09 | 0.83 | 6.87 | 5.4 | 1.5 | $8.28 \times 10^{-4}$ |
| 2. | 4.44 | 0.35 | 5.37 | 4.0 | 1.37 | $3.98 \times 10^{-4}$ |
| 3. | 4.69 | 0.79 | 8.7 | 6.7 | 2.0 | $2.04 \times 10^{-4}$ |
| 4. | 4.69 | 0.98 | 5.5 | 5.3 | 0.25 | $2.04 \times 10^{-4}$ |
| 5. | 4.78 | 0.96 | 4.37 | 3.1 | 1.25 | $1.66 \times 10^{-4}$ |
| 6. | 4.80 | 0.94 | 4.7 | 3.0 | 1.75 | $1.58 \times 10^{-4}$ |
| 7. | 4.91 | 0.66 | 6.05 | 3.3 | 2.75 | $1.23 \times 10^{-4}$ |
| 8. | 5.03 | 0.51 | 4.25 | 2.2 | 2.05 | $9.33 \times 10^{-5}$ |
| 9. | 5.05 | 0.26 | 5.95 | 4.0 | 2.00 | $8.92 \times 10^{-5}$ |
| 10. | 5.32 | 0.83 | 6.12 | 3.6 | 2.5 | $4.78 \times 10^{-5}$ |
| 11. | 5.38 | 0.81 | 5.65 | 3.5 | 2.12 | $4.16 \times 10^{-5}$ |
| 12. | 5.53 | 0.06 | 6.62 | 4.1 | 2.5 | $2.95 \times 10^{-5}$ |
| 13. | 5.70 | 0.79 | 5.9 | 4.7 | 1.25 | $1.99 \times 10^{-5}$ |
| 14. | 5.79 | 0.89 | 5.65 | 5.4 | 0.25 | $1.62 \times 10^{-5}$ |
| 15. | 5.79 | 0.57 | 6.8 | 4.8 | 2.00 | $1.62 \times 10^{-5}$ |
| 16. | 6.15 | 0.66 | 4.55 | 3.1 | 1.5 | $7.07 \times 10^{-6}$ |
| 17. | 6.21 | 0.64 | 4.75 | 4.6 | 0.12 | $6.16 \times 10^{-6}$ |
| 18. | 6.31 | 0.88 | 4.12 | 4.1 | 0.11 | $4.89 \times 10^{-6}$ |
| 19. | 6.35 | 0.89 | 5.0 | 4.9 | 0.12 | $4.46 \times 10^{-6}$ |
| 20. | 6.38 | 0.89 | 6.0 | 5.8 | 0.17 | $4.16 \times 10^{-6}$ |

5.74 whereas soils under banana had 5.10 soil pH. Soils of Lawngtlai had pH variation from 6.03 in Jhums to 4.96 in Tung forest to 5.95 in WRC. In Saiha district, Jhums soil had pH value of 7.24 whereas bamboo soils had soil pH of 6.39 and terraces had soil pH of 5.94. In Champhai, soil pH varied from 5.19 in banana, 5.92 in dry WRC areas to 5.89 in wet WRC. Grapes orchard had soil pH of 5.42, 4.99 and in passion fruit 5.34 .

**Classes of soil acidity :**

All the soil samples varied in their pH levels. Based on their categorization into different acidity groups, majority of soils of Kolasib were having pH between 5 - 5.5 .Based on results, it is concluded that majority of soils of Kolasib were strongly acidic. Twenty five per cent of sampled soils were medium in acidity. Twelve per cent of soils were slightly acidic. But, thirteen per cent of soils were very strongly acidic. And only two per cent of soils were extremely acidic.

**Total acidity :**

It is evident from the Table 1 that total acidity constituted the largest value for all the soils. The values of total acidity ranged from 8.7 meq / 100 g in soil sample number 3 to 4.12 meq/ 100 g in soil sample number 18. The concentration of non-exchangeable acidity ranged from 6.7 meq / 100 g in soil sample number 3 to 2.22 meq/ 100 g in soil sample number 8. It is clear from the Table 1 that the values of non-exchangeable acidity were second highest and next only to total acidity. This form of acidity arises only after the precipitation of the soluble $Al^{3+}$ as $Al(OH)_3$. The non-exchangeable or potential acidity is much higher requiring much larger doses of lime to neutralize than what is needed for neutralization of active acidity.

Exchangeable acidity values ranged from 2.75 meq / 100 g in soil sample number 7 to 0.110 meq / 100 g in soil sample number 18. The data presented in Table 1 also showed that as the pH increased from 5.70 (in soil sample number 13) onwards, the values of exchangeable acidity decreased. This is due to the fact that in strongly acidic soil, the concentrations of exchangeable $Al^{3+}$ and $H^+$ ions contribute to exchangeable acidity. The acidity developed in such soils is due to absorbed $H^+$ and $Al^{3+}$ ions on soil colloids. However, exchangeable $Al^{3+}$ and $H^+$ were negligible in moderately to slightly acidic soils.

**Active acidity :**

This form of acidity is the actual $H^+$ ion concentration in soil solution measured by a pH meter. The concentration of active acidity varied widely as decrease of one unit of pH is equal to 10 times increase in $H^+$ ion concentration in the soil solution. It is evident from the Table 2 that as the pH decreased from 6 to 5 $H^+$ ion concentration increased from 10 times and as pH decreased from 6 to 4, $H^+$ ion concentration increased from 100 times. In the present study, active acidity varied from $7.07 \times 10^{-6}$ meq / 100 g in soil sample number 17 to $8.28 \times 10^{-4}$ meq/100g in soil sample number 1.

In general, the different forms of acidity detected in Kolasib soils can be arranged in decreasing manner as: Total acidity > Non-exchangeable acidity > Exchangeable acidity > Active acidity.

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